Customized FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY DOCKET NO: P07336US00/LRP

U.S. APPLICATION NO (If known, see 37 CFR 1.5): 09/913402

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP00/02156	03 APRIL 2000	02 APRIL 1999

TITLE OF INVENTION: SUPPRESSANT AGAINST VASCULAR RESTENOSIS OF BLOOD VESSEL . . .

APPLICANT(S) FOR DO/EO/US: NAGAE, Tsuneyuki et al.

Applicant herewith submits to the US Designated/Elected Office (DO/EO/US) the following items and other information.

- ☒ 1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
- ☐ 2. This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371.
- ☒ 3. This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Art. 22 and 39(1).
- ☒ 4. A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
- ☒ 5. A **copy** of the International Application as filed (35 U.S.C. 371 (c)(2))
  - ☐ a. is transmitted herewith (required only if not transmitted by the International Bureau).
  - ☒ b. has been transmitted by the International Bureau.
  - ☐ c. is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ 6. A **translation** of the International Application into English (35 U.S.C. 371(c)(2)).
- ☒ 7. Amendments to the claims of the International Appln. under PCT Article 19 (35 USC 371 (c)(3))
  - ☐ a. are transmitted herewith (required only if not transmitted by the International Bureau).
  - ☐ b. have been transmitted by the International Bureau.
  - ☐ c. have not been made; however, the time limit for making such amendments had NOT expired.
  - ☒ d. have not been made and will not be made.
- ☐ 8. A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- ☒ 9. An **oath** or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
- ☐ 10. A translation of the annexes to the Int'l Prelim. Exam. Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

- ☐ 11. An **Information Disclosure Statement** under 37 C.F.R. 1.97 and 1.98.
- ☒ 12. An **Assignment** document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
- ☐ 13. A **First preliminary amendment**.
- ☐ 14. A Second or Subsequent preliminary amendment.
- ☐ 15. A substitute specification.
- ☐ 16. A change of power of attorney and/or address letter.
- ☐ 17. A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 & 35 USC 1.821-825.
- ☐ 18. A second copy of the published international application under 35 USC 154(d)(4).
- ☐ 19. A second copy of the English translation of the international application under 35 USC 154(d)(4).
- ☐ 20. Other items or information:
  - ☐
  - ☐

- ☐ A copy of the Notification of Missing Requirements under 35 U.S.C. 371.
- ☐ In the event that a petition for extension of time is required to be submitted herewith, and in the event that a separate petition does not accompany this response, applicant hereby petitions under 37 CFR 1.136(a) for an extension of time of as many months as are required to render this submission timely. Any fee is authorized in 17(c).

Date: 14 August 2001

LARSON & TAYLOR, PLC • 1199 North Fairfax St. • Suite 900 • Alexandria, VA 22314

533 Rec'd PCT/PTO 14 AUG 2001

U.S. APPLICATION NO. (If known)	INTERNATIONAL APPLICATION NO.	ATTORNEY DOCKET NO.
09/913402	PCT/JP00/02156	P07336US00/LRP

		CALCULATIONS PTO USE ONLY
☒ 21. **The following fees are submitted:**		
☒ **Basic National Fee** (37 CFR 1.492 (a) (1)-(5):		
☐ Neither Int'l Prelim. Exam. fee nor Int'l Search fee paid to USPTO	$1000	
☒ Search Report has been prepared by the EPO or JPO	$ 860	
☐ No Int'l Prelim. Ex. fee paid to USPTO but Int'l Search fee paid to USPTO	$ 710	
☐ International preliminary examination fee paid to USPTPO	$ 690	
☐ Int'l Prelim. Ex. fee paid to USPTO & all claims satisfied PCT Art. 33(1)-(4)	$ 100	
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 860
☐ Surcharge of **$130** for furnishing the oath or declaration later than ☐ 20 mos. ☐ 30 mos. + from the earliest claimed priority date (37 CFR 1.492(e)).		$

CLAIMS	*NUMBER FILED*	*NUMBER EXTRA*	*RATE*	
Total Claims	4 - 20 =		X **$18** =	$
Independent Claims	2 - 03 =		X **$80** =	$
☐ Multiple Dependent Claim(s) (if applicable)			+ **$270** =	$
TOTAL OF ABOVE CALCULATIONS =				**$** 860
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.			-	$
SUBTOTAL =				**$** 860
☐ Processing fee of **$130** for furnishing the **English translation** later than ☐ 20 mos. ☐ 30 mos. + from the earliest claimed priority date (37 CFR 1.492(f)).				$
TOTAL NATIONAL FEE =				**$** 860
☒ Fee for recording the enclosed **assignment** (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40** per property			+	$ 40
TOTAL FEES ENCLOSED =				**$** 900
Amount to be				*Refunded* $
				Charged $

☒ a. A **check** in the amount of $ 900 to cover the above fees is enclosed.

☐ b. Please charge my Deposit Account No. 12-0555 in the amount of $ to cover the above fees.

☒ c. The Commissioner is hereby authorized to charge any additional fees required or credit overpayment to Deposit Account No. 12-0555.

Note: *Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.*

SEND ALL CORRESPONDENCE TO:

LINDA R. POTEATE

At the address (below) of **CUSTOMER NO. 00881.**

LARSON & TAYLOR, PLC
1199 NORTH FAIRFAX ST.
SUITE 900
ALEXANDRIA, VA 22314

SIGNATURE: Douglas E. Jackson

NAME: Douglas E. Jackson

REG. NO.: 28518

PHONE NO.: 703-739-4900

Date: 14 August 2001

533 Rec'd PCT/PTO 14 AUG 2001
09/913402

4/PRTS

DESCRIPTION

SUPPRESSANT AGAINST VASCULAR RESTENOSIS OF BLOOD VESSEL INDUCIBLE AFTER ANGIOPLASTY

TECHNICAL FIELD

This invention relates to a vascular restenosis-suppressing composition which acts as a photosensitive agent and exhibits a therapeutic effect of suppressing a thickening of the vascular intima of the blood vessel at a site thereof having received an angioplasty treatment, and which composition is for use in a photochemotherapy or photo-dynamic therapy (abbreviated to PDT) to be performed for the purpose of suppressing the vascular restenosis of the angioplasty-dilated site of the blood vessel which is inducible due to a thickening of the vascular intima of the blood vessel, after the narrowed or stenosed site of the blood vessel had been dilated by an angioplasty treatment according to percutaneous transluminal coronary angioplasty (abbreviated as PTCA) or percutaneous transluminal angioplasty (abbreviated as PTA).

This invention also relates to a novel method for suppressing a vascular restenosis, which is effected according to a photochemotherapy or photodynamic therapy, and which is performed for suppressing the vascular restenosis of the blood vessel at a site thereof having

received the angioplasty treatment, from being induced due to the thickening of the vascular intima of the angioplasty-dilated site of the blood vessel, as stated above.

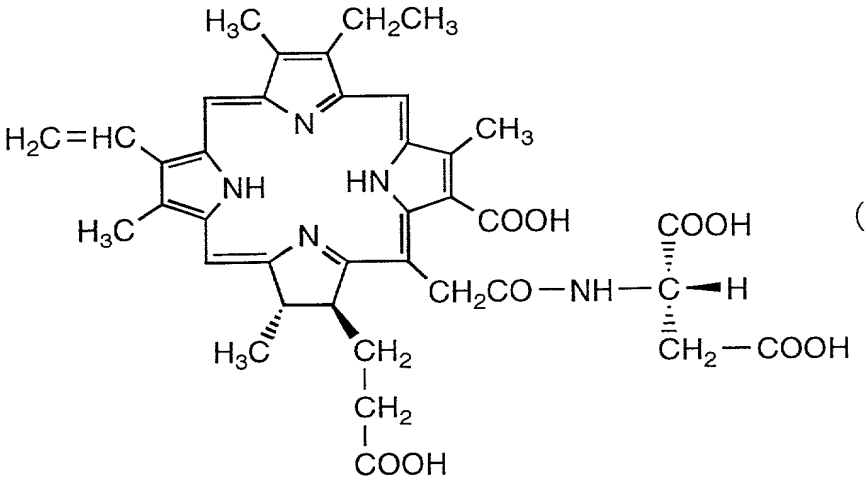
BACKGROUND ART

Photodynamic therapy (hereinafter, referred to as PDT) is a chemotherapeutic method which comprises initially administering such a photosensitive substance that is activatable by irradiation with ultraviolet ray or laser light; and then activating the administered photosensitive substance, for example, by irradiation of the light or laser to said photosensitive substance present in the lesion of the living body where the administered photosensitive substance has accumulated, or said photosensitive substance present in the blood containing the photosensitive substance, so as to produce the cytotoxic effect of the photosensitive substance, whereby said lesion is treated photo-therapeutically (Ann. Vasc. Surg., Vol. 9, pp.80-86 (1999) and Cardicovasc. Surg., Vol. 3, pp.489-494 (1995).

Japanese Patent Publication No. Hei-6-88902 and No. Hei-6-89000 describe the use of fluorescent tetrapyrrole derivatives, for example, mono-L-aspartylchlorin e6 and mono-L-glutamylchlorin e6 or salts thereof, as a photosensitive agent for the diagnosis and therapeutic treatment of tumor by PDT.

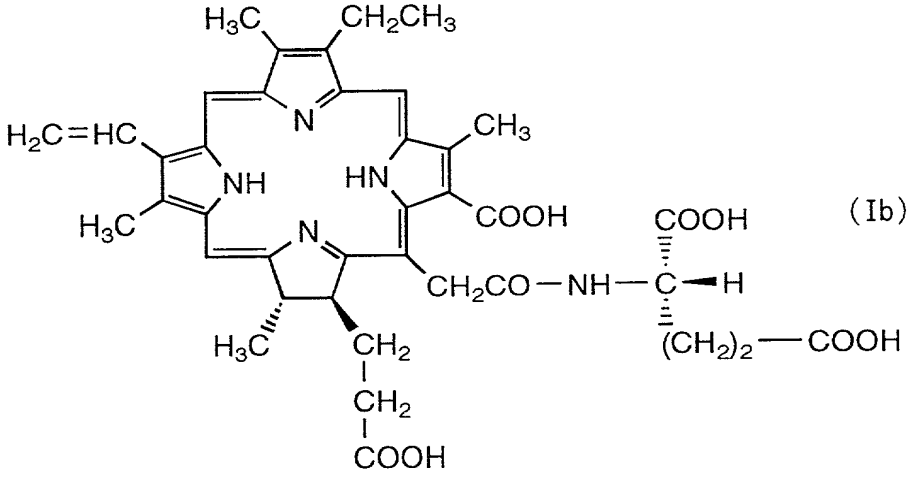
Mono-L-aspartylchlorin e6 is the compound represented

by the formula (Ia)



(Ia)

Mono-L-glutamylchlorin e6 is the compound represented by the formula (Ib)



(Ib)

The above-described fluorescent tetrapyrrole compounds have been reported to be used as the photosensitive agent in PDT for arteriosclerosis, because they can effect their selective accumulation in the lesions of arteriosclerosis, including such coronary

arteriosclerosis which can induce myocardial infarction and angina, as well as such cerebral arteriosclerosis which can induce transient cerebral ischemia and cerebral infarction. Said tetrapyrrole compounds have been reported to exhibit some therapeutic effects for the arteriosclerosis (Japanese Patent Laid-Open publication No. Hei-4-330013 and U.S. Patent No. 5308861).

On the other hand, in the treatment of ischemic arterial diseases induced by the arteriosclerosis, a treatment by PTCA or PTA is generally used for dilating the narrowed or stenosed sites or lesions of arterial vessels. For this purpose, an intravascular catheter may be used. There is, however, a problem that after the angioplasty operations, a vascular restenosis can be induced at the angioplasty-dilated site of the blood vessel at a rate of from 30% to 60% of the angioplasty operations. Vascular restenosis occurs due to a neo-intimal thickening which is caused by proliferation and migration of the smooth muscle cells in the tunica media of blood vessel at said site. The mechanism of onset of the neo-intimal thickening is now postulated to be as follows. Thus, during the process of dilating the narrowed or stenosed site of the vascular vessel having the arteriosclerotic lesions which was effected by means of a balloon catheter according to PTCA or PTA, it occurs that the vascular endothelial cells and their surrounding tissues at said site are intervened and

injured by the inflated balloon of the balloon catheter and thus the subendothelial tissues of the blood vessel wall at said site are barely exposed, resulting in the activation of platelets. As an outcome of the biological reactions of repairing the balloon-injured site at said lesions, the so activated platelets can adhere to the balloon-injured site and can agglutinate, and will release the smooth muscle growth factors, such as PDGF (platelet-derived growth factor) and TGF-β (transforming growth factor). In addition, macrophages can infiltrate into said balloon-injured site and release a variety of the growth factors. These biological processes can trigger the differentiation, proliferation, and migration of the smooth muscle cells in the tunica media at said site of the blood vessels, which can further involve stimulations of the intimal smooth cells for forming the vascular neo-intima, so that the intimal smooth cells themselves will release the growth factors. In this way, an intimal thickening which lasts for a long period of time can be produced in the blood vessel at said site. As a result, the vascular restenosis can be involved (a Japanese journal: Kekkan to Naihi, Vol.6, pp.56-64 (1996).

Up to now, it has been found from certain animal tests that some of drugs, such as antiallergic drugs, ACE-inhibitors, angiotensin II-antagonists, antiplatelet drugs, PDE III-inhibitors, have a suppressive effect on

the vascular intimal thickening which is induced post to the PTCA or PTA treatment (Japanese Patent Laid-Open publications No. Hei-9-188619, No. Hei-8-176013 and No. Hei-7-25768).

The mechanism of the pharmacological action of the above-mentioned drugs as tested comprises suppression and inhibition against the processes of the mechanism of onset of the vascular intimal thickening which are described in the above. However, the mechanism of the pharmacological action of the tested drugs above can be developed in different ways between animals and human, resulting in some great difference in the medicinal efficacy of the above drugs. Currently, in the therapeutic process for preventing the vascular restenosis which is conducted in clinical practice, there is carried out also a variety of supplementary therapies by administration of drug and occasionally concomitant insertion of a stenting device is done, in order to ensure that a favorable outcome can be attained. Still, however, the thus attainable outcome is not yet satisfactory. Therefore, there remains a demand for providing a more effective therapeutic method which is able to suppress surely the vascular restenosis at a site of the blood vessel having received a PTCA or PTA treatment (Dtsch. Med. Wschr, Vol. 123, pp.840-846 (1998).

On the other hand, as the photosensitive agent for

PDT, Photofrin is currently used in the clinical treatment of cancer. When Photofrin is used, it is necessary that a time interval to be interposed between the administration of Photofrin and the commencement of light irradiation should be adjusted to be of a time period of 48 to 72 hours. Photosensitive reactions which would be caused in the patients by the administered Photofrin can continue longly for four weeks, and therefore it is required that the time period necessary for the shielding of the patients from lights should be kept for 4 weeks after the administration of Photofrin. This can result in that the hospitalization of patients must be made for a considerably long time period and can lower QOL (Quality of Life) of the patients (THE JOURNAL OF JAPAN SOCIETY FOR LASER SURGERY AND MEDICINE, Vol. 18, pp.295-300 (1997). While, when mono-L-aspartylchlorin e6 or its tetrasodium salt is used for PDT for the cancer treatment, the time interval to be interposed between the drug administration and the commencement of laser irradiation can advantageously be adjusted to be as short as 4 to 6 hours, and further the time period as required to attain the disappearance of the photosensitive reactions caused by the administered chlorin e6 compound may be shorter in the order of two weeks, which is a half of that required for Photofrin.

The present inventors had previously reported such a therapeutic method for suppressing the vascular

restenosis by application of PDT, which method comprised effecting an intravascular irradiation of laser light onto the blood vessel at a site thereof having received an angioplasty treatment (for example, according to PTCA or PTA), with using such a cylindrical optical fiber for the intravascular laser irradiation that had been inserted into and kept in the blood vessel (see The 62nd Scientific Meeting of Japanese Circulation Society, Abstract, p.465 (1988)). The above-mentioned therapeutic method as previously reported by the present inventors, however, has not yet attained such therapeutic effect that a complete and steady suppression can successfully be achieved against the vascular restenosis of the blood vessel as dilated by a PTCA or PTA treatment, which is inducible at the intravascular site having received the PTCA or PTA treatment.

Therefore, there is still remaining a demand for developing a new, photodynamic therapy method which is capable of suppressing completely the vascular restenosis inducible after angioplasty such as PTCA or PTA, and which method is able to treat selectively in a simple and efficient way solely the blood vessel site having received the angioplasty treatment, according to a PDT process comprising intravascular irradiation of laser, and which method also can readily be applied in clinics. There remains also a demand for providing a new vascular restenosis-suppressing pharmaceutical

composition which is capable of acting as a photo-sensitive agent suitable for use in the aforesaid new photodynamic therapy method for suppressing the vascular restenosis.

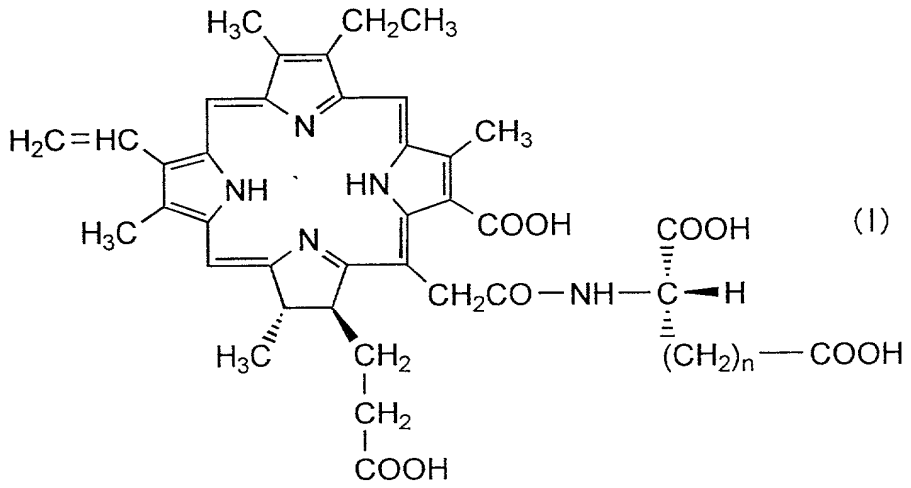
DISCLOSURE OF THE INVENTION

Thus, the present inventors have now made investigations to provide such new suppressant or preventive agent for treating the vascular restenosis, which is able to meet the above-mentioned demands. As a result, the present inventors have now found that, when the above-mentioned mono-L-aspartylchlorin e6 or its tetrasodium salt is intravenously administered to a patient whose blood vessel has received an angioplasty treatment by PTCA or PTA, and when the dose of administration of said chlorin e6 compound for adult patient is adjusted to a dosage of 0.01-50 mg/kg, preferably a dosage of 0.1-5 mg/kg, the so administered mono-L-aspartylchlorin e6 or its tetrasodium salt is able to accumulate preferentially in the smooth muscle cells in the tunica media and intima of the blood vessel at a site thereof having received the PTCA or PTA treatment within a time of 10 minutes to 6 hours after the administration of said chlorin e6 compound. The present inventors now have also found that the amount (or concentration) of the mono-L- aspartylchlorin e6 which has thus accumulated in the layers of the vascular smooth muscle cells at said PTCA or PTA-treated site is

sufficient, upon having received the intravascular irradiation of laser at 664 nm, to generate and exert stably such therapeutic effects that the intimal thickening of the blood vessel is inhibited at the intravascular site having received the PTCA or PTA treatment, with suppressing the vascular restenosis inducible at said site.

It also has been found that mono-L-glutamylchlorin e6 or its tetrasodium salt can exhibit the same effects as above when it is used in the same manner as mono-L-aspartylchlorin e6 or its tetrasodium salt.

Thus, in a first aspect of the invention, there is provided a vascular restenosis-suppressing composition, which is for use as a photosensitive agent in a method of suppressing the vascular restenosis inducible at an angioplasty-dilated site of a blood vessel having received a percutaneous transluminal coronary angioplasty or a percutaneous transluminal angioplasty, by means of a photodynamic therapy process comprising intravascular irradiation of laser, and which composition exhibits a suppressing effect on a thickening of the vascular intima in the interior of the blood vessel wall at the angioplasty-dilated site of the blood vessel, characterized in that said composition comprises mono-L-aspartylchlorin e6 or mono-L-glutamylchlorin e6 having a general formula (I)



(I)

wherein n is an integer of 1 or 2, or a pharmacologically acceptable salt thereof, as an active ingredient.

Of the compounds having the above general formula (I), the compound where n=1 is such one in which L-aspartic acid is coupled at its amino group, with a group $-CH_2COOH$ present as a side chain of the tetrapyrrole ring, via the amido-linkage, and which compound is mono-L-aspartylchlorin e6. Preferably, this compound is in the form of tetrasodium salt at the four carboxyl groups thereof. Of compounds having the above general formula (I), the compound where n=2 is such one in which L-glutamic acid in place of L-aspartic acid is coupled via the amido-linkage, and which compound is mono-L-glutamy-lchlorin e6.

The compound of general formula (I) which is used as an active ingredient in the composition of this invention may combine with a base to form a salt. Its

salts which may be formed by reaction of the chlorin e6 compound of the formula (I) with a base include those with sodium, potassium, calcium, magnesium, ammonium, triethyl-ammonium, trimethylammonium, morpholine, and piperidine.

Disorders for which the composition of this invention is administered may be such vascular restenosises which are inducible at any dilated sites of the narrowed or stenosed parts of the blood vessels in various tumors or in the disordered ocular fundus with age-related macular degeneration, as well as the stenosed parts of the blood vessel with atherosclerosis in the peripheral blood vessels of limbs, coronary artery and cerebral artery. Such vascular restenosis may include, for example, the vascular restenosis inducible after surgical operations of implanting a stenting device, venous graft or artificial blood vessel, as well as the vascular restenosis as resulted from the vascular intimal thickening caused by the treatment according to angioplasty.

The compound of formula (I) usable as an active ingredient in the composition of this invention can be administered orally or parenterally by intravenous or intramuscular injection. It can be also administered percutaneously. For example, the composition of this invention may contain the compound of the active ingredient in the form of its sodium salt and may be

formulated as a lyophilized and sterile preparation which is free from pyrogen.

With the composition of this invention for oral administration, `the active ingredient compound may be mixed with a solid or liquid carrier and may be formulated in the form of tablets, buccal tablets, troches, capsules, suspensions, syrups, or the like.

A proportion of the chlorin e6 compound as the active ingredient contained in the composition of this invention may depend on a dosage form, but may conveniently be in the range of about 2-60% by weight of a unit dosage.

Preferred forms of the injectable preparation made of the composition of this invention include a sterile solution or a dispersion containing the chlorin e6 compound as the active ingredient, as well as a sterile, lyophilized preparation. Preferably, the carrier may be, for example, water, ethanol, glycerol, propylene glycol, vegetable oil, or the like. In many cases, preferably, an isotonic agent such as sugar or sodium chloride, may be incorporated.

In the case of the injectable preparation made of the composition of the invention, there may further be added such an agent for delaying the absorption of the chlorin e6 compound as the active ingredient, which is, for example, aluminum monostearate or gelatin.

The dosage of the administration of the chlorin e6

compound, which is used as the active ingredient in the composition of the invention, may depend upon the purpose of the therapeutic treatment, but the active chlorin e6 compound may be administered usually at a dosage of 0.01-50 mg/kg of body weight, preferably at a dosage of 0.1-5 mg/kg of body weight at one time for adults.

The PDT method may be conducted in such way that the intravascular irradiation of light is applied to the angioplasty-dilated site of the originally stenosed lesion of the blood vessel at the end of a time lapse of several minutes to tens of hours, preferably 0.5-6 hours after the administration of mono-L-aspartylchlorin e6 or its tetrasodium salt was made. The light-irradiating source for PDT is not limited specifically, but is preferably a laser ray-irradiating source.

For the irradiation of the laser ray, a strong and continuous laser-generating source with a filter, or an activated pigment or other laser-source, in association with a laser-delivery system is used. As the irradiating laser, a laser is used at the wavelength of 360-760 nm, preferably 560-760 nm, more preferably 664 nm. The irradiance of the laser may suitably be selected, and is usually in the range of 10-1000 mW/cm^2, preferably 20-500 mW/cm^2. The fluence (J/cm^2) of the laser may be calculated to express a mathematical product of the irradiance (W/cm^2) by the irradiation time (sec.) of the

irradiating laser, in term of the mathematical product that is J = W × sec. In the case when the tumor treatment was made by PDT, a fluence of 50-200 J/ cm^2 was usually used for the laser. In contrast, a lesser fluence of 1-100 J/ cm^2 is enough for the laser irradiation which is intended to suppress the vascular restenosis by means of the composition according to this invention.

As stated above, the therapeutically effective and sufficient amount of mono-L-aspartylchlorin e6 or its tetrasodium salt as administered is able to accumulate preferentially just in the blood vessel wall at the PTCA or PTA-treated site thereof, already at such a time point at which a relevant time period has lapsed after the administration of said chlorin e6 compound given at its appropriate dose to the patient having the blood vessel treated by PTCA or PTA.

Mono-L-aspartylchlorin e6 or its tetrasodium salt, which has thus accumulated in the wall of the blood vessel at the site having received the PTCA or PTA treatment, is able to be photo-activated with the irradiating laser, when the chlorin e6 compound has received a sufficient fluence of the laser by the intravascular irradiation of the laser which has passed through an optical fiber provided in such a laser-irradiating device that had been constructed in the form of an intravascular catheter and that has been inserted

and retained in the blood vessel having received the PTCA or PTA treatment; and also when the chlorin e6 compound as administered has continued to be remaining in the cells of the blood vessel wall at the site having received the PTCA or PTA treatment.

The chlorin e6 compound so photo-activated with laser which is remaining in the cells of said blood vessel wall at the PTCA or PTA-treated site is then able to generate and exert the aforesaid cytotoxic effect on the smooth muscle cells in the tunica media and intima of the blood vessel walls at said site, and is thus able to bring about the suppressing effect against the intravascular intimal thickening and hence the suppressive effect against the vascular restenosis.

However, there occurs such problem that the chlorin e6 compound which has accumulated in the cell layers of the blood vessel wall would not be able to generate their intended effects, so long as the chlorin e6 compound present in said cell layers should have not yet received the irradiating laser at a high laser fluence which would be necessary and sufficient to bring about the photo-activation of said chlorin e6 compound. In addition, it has now been found that, as long as the aforesaid cylindrical optical fiber employed in the previous method is used for the laser irradiation as reported previously, necessary centering of the aforesaid cylindrical optical fiber within the blood

vessel, which is to be done for placing the longitudinal axis of the cylindrical optical fiber to be positioned just coincidently with the central axis of the blood vessel lumen, is difficult to be achieved. It has also be observed that if said centering of the cylindrical optical fiber within the blood vessel has not been achieved, then the transmission of the irradiating laser could also be interfered by the bloodstream (and the drug present in the blood) so as to disturb the arrival of the irradiating laser to the blood vessel inner wall; and that consequently, the suppressive effects of the photoactive chlorin e6 compound on the vascular restenosis, which will be obtainable by the use of the aforesaid cylindrical optical fiber, can be varying greatly and become to be too insufficient, depending upon where the particular location of the blood vessel site is to be treated.

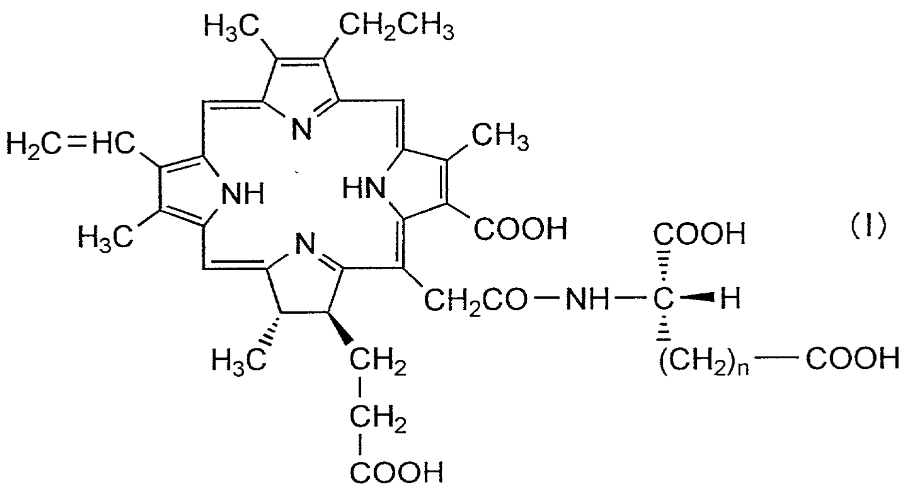
Accordingly, there are incurred further problems which need to be resolved and which require the present inventors to try to discover such conditions for PDT that can ensure the laser to be irradiated at a constant and steady fluence uniformly within the blood vessel during the process of the PDT. These problems necessitate the present inventors to develop such a new method which can ensure the vascular restenosis-suppressing effects of mono-L-aspartylchlorin e6 to be achieved and exerted to the full extent.

To solve the above problems, the present inventors have now conducted further investigation. As a result of the extensive investigation, it has now been found and confirmed that, when an effective amount of mono-L-aspartylchlorin e6 is administered as the photoactive agent for PDT; and when there are subsequently conducted such procedures of PDT, wherein use is made of a laser-irradiating device which comprises a known type of balloon catheter having therein a central and longitudinal hole and which device is equipped with a laser-irradiating optical fiber of a thin diameter as provided in the balloon catheter and so arranged as to extend within and through said central hole of the balloon catheter; wherein said laser-irradiating device is inserted in the blood vessel and be held in such a position that the balloon of the balloon catheter of said device as inserted in the blood vessel is placed to be located oppositely to the PTCA or PTA-treated site of the blood vessel; wherein the balloon of the catheter is then inflated by delivery of an inflating liquid medium thereinto so that the inflated balloon so produced of the balloon catheter can have generated the force for supporting the balloon catheter firmly on the blood vessel inner wall, thereby to allow the longitudinal axis of the optical fiber provided in the balloon catheter of said device to be held coincidently with and in the same position as the longitudinal axis of the

vascular lumen of said blood vessel at the angioplasty-treated site thereof; wherein there are thus produced such resultant conditions that the inflated balloon of the balloon catheter can have removed the unfavorable interference by the blood stream which is to disturb a uniform, intravascular irradiation of the laser emitting from the optical fiber provided in the balloon catheter; and wherein the intravascular irradiation of the laser for PDT is next effected under the said resultant conditions, it is only then made feasible that the administered chlorin e6 compound can be photo-activated sufficiently to stably and evenly bring about and exert its own suppressive effects against the intimal thickening of the blood vessel at said PTCA or PTA-treated site thereof.

According to a second aspect of the invention, therefore, there is provided a photodynamic therapy method of suppressing such thickening of the vascular intima in the blood vessel wall and also such vascular restenosis of the blood vessel which are inducible after the angioplasty treatment of the blood vessel has been done, which method comprises:-

administering mono-L-aspartylchlorin e6 or mono-L-glutamylchlorin e6 of the general formula (I)



(I)

wherein n is 1 or 2, or a salt thereof, to a patient whose blood vessel has received the treatment by angioplasty;

making the administration of the compound of the formula (I) at a dosage so adjusted that a therapeutically effective amount of the compound of formula (I) can accumulate in the cell layers of the blood vessel wall at the site of the blood vessel having received the treatment by angioplasty;

inserting percutaneously and transluminally into and locating in the interior of said blood vessel at the position of the site thereof having received the treatment by angioplasty, such a laser-irradiating device that comprises a balloon catheter having a central and longitudinal hole therein and having an inflatable balloon made of a laser-transmissive material at the front end of said catheter and that comprises a laser-irradiating optical fiber so arranged as to extend

within and through said central and longitudinal hole in the balloon catheter and is equipped on the catheter with an inlet tube for introduction of an inflating liquid to be sent into the interior space of said inflatable balloon; and adjusting the position of the balloon catheter within the blood vessel so that said balloon of the balloon catheter is located oppositely to the angioplasty-treated site of the blood vessel;

making said balloon of the balloon catheter inflate by delivery of the inflating liquid in the interior space of the balloon of the catheter via said inlet tube for introduction of the inflating liquid into the balloon interior space of the catheter of said device, thereby to produce the inflated balloon in the balloon catheter ;

allowing the central axis of the laser-irradiating optical fiber present within the central and longitudinal hole of said balloon catheter to be held coincidently with and in the same position as the central axis of the vascular lumen of the blood vessel at the angioplasty-treated site of the blood vessel, with aid of such a supporting force which is generated by said inflated balloon to be exerted on the balloon catheter and on the inner wall of the blood vessel at said angioplasty-treated site;

and irradiating the compound of formula (I) having accumulated in the interior of the blood vessel wall

positioned at the angioplasty-treated site of the blood vessel, with a laser light of an appropriate wavelength, by transmitting from a laser-generator the laser light via said optical fiber in the balloon catheter, in such a manner that the transmitted laser light is emitted outwardly from the laser-emitting part at the front end of said optical fiber and is made to pass through the liquid medium present in the inflated balloon and through the wall material of said inflated balloon of the balloon catheter, so that the emitted laser light irradiates the compound of formula (I) present in the blood vessel inner wall, whereby said compound so irradiated is photoactivated and allowed to generate and exert the suppressive effects thereof against the thickening of the vascular intima in the angioplasty-treated site of the blood vessel.

In order to assemble or construct the laser-irradiating device which comprises the balloon catheter and is used in the method of the second aspect of this invention and in which the laser-irradiating and transmitting optical fiber is provided and arranged in the interior of the hole of the known type of balloon catheter, it is possible to employ anyone of the commercially available or known optical fibers which are usually used for the laser irradiation in the PDT treatment of tumors formed in the esophageal mucous membrane or pulmonary trachea. The optical fiber as

employed may be inserted and arranged in an appropriately way in the central longitudinal hole present in a commercially available or known balloon catheter. The balloon catheter has usually been employed in conventional methods for conducting a percutaneous transluminal coronary angioplasty (PTCA) or percutaneous transluminal angioplasty (PTA).

In the method of the second aspect of this invention, commercially available or known devices usable for PDT may be used appropriately, in combination, to assemble or construct from them the laser-irradiating device which is to be used in the present method. Any of the laser-irradiating devices may be constructed and used in the method of the invention, as long as the laser-irradiating device so constructed is able to achieve its performances that can satisfy the following three criteria: 1) the balloon membrane of the balloon catheter as arranged in said device is made of a laser-transmissive material; 2) the central axis of the internal optical fiber for transmission of the irradiating light can be held coincidently with and in the same position as that of the central axis of the vascular lumen of the blood vessel, by making the balloon inflated, so that the irradiating laser having emitted from said optical fiber is allowed to be applied evenly onto the blood vessel inner wall; and 3) the flowing of the bloodstream can be stopped in the blood

vessel by the inflated balloon.

When a blood vessel having a large caliber, such as the aorta of lower limbs, is to be treated as a target for PDT, there may be employed also such balloon catheter having the laser-irradiating optical fiber and having the balloon, which is commercially available to be used in the PDT treatment of pulmonary cancer and esophageal carcinomas.

In the method of the second aspect of this invention, it is possible to effect the laser irradiation by means of a laser-irradiating device in which a linear optical fiber for irradiation of laser has been inserted in the central hole of a commercially available balloon catheter known for use in the various intervention procedures. For example, in "Eur J Vasc Endovase Surg" Vol.16(4), p.284-291 (1988), there is disclosed a method for effecting the laser irradiation by means of such a laser-irradiating device which has been assembled by removing a guide-wire out of the central hole of the balloon catheter conventionally used for PTA and then inserting a linear optical fiber in the empty hole of the balloon catheter in place of said guide-wire.

Similarly, when the coronary artery is treated as a target for PTCA, it is possible that there is employed such a balloon catheter which is equipped with a guide-wire and has the same structure as that of a

commercially available balloon catheter usable conventionally for PTCA, and of which the balloon is made of a laser transmissive-material, and also it is possible that the PTCA procedures are then effected by means of said balloon catheter, and that subsequently to the PTCA procedures, a laser-irradiating linear optical fiber of a thin diameter is inserted through the guide-wire-introducing inlet and slot of said balloon catheter into the central hole of the balloon catheter so as to assemble a laser-irradiating device which may be employed for carrying out the second aspect method of this invention.

In addition, it is possible in this invention that an X-ray marker made of a suitable X-ray-shielding material is attached to one end of the laser-irradiating optical fiber for the purpose of permitting the position of the optical fiber to be detectable by X-ray radiography. Additionally, use may be made of such a laser-irradiating device which has a structure so modified as to permit the blood stream of the coronary artery to be maintained at a suitable level, if said device can meet the purposes as intended in the second aspect method of the invention. Currently, when a balloon catheter is used in angioplasty, concomitant use of a stenting device can provide some success. The PDT method of this invention may be also carried out in association with a stenting device which has been

implanted in the blood vessel.

Figure 1 of the appended drawings shows a diagrammatical view of the longitudinal cross-section of such a laser-irradiating device which comprises a balloon catheter and can be used in the second aspect method of this invention and which is insertable into the interior of the blood vessel. The laser-irradiating device of Figure 1 comprises the balloon catheter (1) and an optical fiber (3) for transmission and irradiation of the laser, wherein the front end of the optical fiber (3) is equipped with a laser emitter (3') which connects with the optical fiber (3). The optical fiber (3) with its laser emitter (3') has been inserted and located firmly in the interior of the central and longitudinal hole of said balloon catheter (1) which has a sheath structure and is made of synthetic resin, which is commonly used for the treatment according to percutaneous transluminal coronary angioplasty (PTCA) or percutaneous transluminal angioplasty (PTA), which is provided with a cylindrical and empty jacket (1') and with the central and longitudinal hole (6) (not shown). Further, the optical fiber (3) has been adhered to the inner wall (1") of the hole of the balloon catheter (1), so that the laser-irradiating device so assembled has a wholly integrated structure.

In the structure of the device of Figure 1, the laser emitter (3') connected to the optical fiber (3) is

so arranged that the emitter (3') is placed in a position to oppose to the balloon-forming part (2) of the balloon catheter (1). Towards the rear end of the balloon catheter (1) is provided an inlet tube (4) for introduction of the inflating liquid (for example, sterile physiological saline) which is to be injected and delivered into the empty jacket (1') of the balloon catheter in order to inflate the inflatable balloon of the catheter. When the inflating liquid has been injected into the jacket (1') and delivered in the balloon-forming part (2), the balloon-forming part (2) can be extended and inflated by the hydraulic pressure of the inflating liquid to produce the expanded balloon of the balloon catheter.

Figure 2 of the appended drawings shows a diagrammatical view of the longitudinal cross-section of the laser-irradiating device of Figure 1 and the cross-section of the blood vessel, when the said device have had the expanded or inflated balloon (2') which has been produced by inflation of the balloon-forming part (2) with the inflating liquid as injected and delivered after the previous insertion of the laser-irradiating device of Figure 1 in the blood vessel (5).

As shown in Figure 2, the balloon catheter (1), which is equipped with the optical fiber (3) and provided in the laser-irradiating device, has the completely inflated balloon (2'), of which the top

surface has been brought into a close contact with the inner wall (5′) of the blood vessel (5) with being pressed outwardly under the resulting hydraulic pressure of the inflating liquid as delivered to fill the inflated balloon (2′). The completely inflated balloon (2′) has generated and exerted the force for supporting the optical fiber (3) of the balloon catheter, since it has received the hydraulic pressure of the inflating liquid as delivered therein. Thus, the laser-irradiating device as a whole is allowed to be located firmly in the interior of the blood vessel in such way that the central axis of the optical fiber (3) can be held and maintained coincidently with and in the same position as that of the central axis of the vascular lumen of the blood vessel.

Figure 3 of the appended drawings shows a diagrammatical view of the longitudinal cross-section of a sheath-insertable balloon catheter made of synthetic resin, which is commonly used for PTCA or PTA and which is provided with a cylindrical and empty jacket (1′) and also with a central and longitudinal hole (6) therein. The balloon catheter as shown in Figure 3 has such structure that it may be formed by depriving the optical fiber and its laser emitter from the laser-irradiating device as shown in Figure 1.

The balloon catheter (1) shown in Figure 3 has an empty jacket (1′), a balloon-forming part (2), an inlet

tube (4) for introduction of the inflating liquid and a central and longitudinal hollow hole (6). The balloon catheter shown in Figure 3 may be firstly inserted percutaneouly and transluminally into the blood vessel by means of a usual sheath usable for intravascular insertion of the balloon catheter. By subsequently inserting a guide-wire in the hollow hole of the balloon catheter and using said guide-wire as a guide according to the known technique of PTCA or PTA, said balloon catheter once inserted as above may then be moved to reach such site of the blood vessel which is predetermined to be treated by the second aspect method of this invention. Subsequently, said balloon catheter as inserted is located firmly in position at said site to be treated. Thereafter, the guide-wire is drawn out off from the hole of said balloon catheter. An optical fiber of a thin diameter is then inserted in and through the emptied hollow hole (6) of the so located balloon catheter to fill the inner hole of the balloon catheter, so that a laser-irradiating device usable in the second aspect method of this invention can be assembled and constructed by combining the necessary members of said laser-irradiating device within the blood vessel.

Next, the procedures for using the laser-irradiating device of Figure 1 and for carrying out the second aspect method of this invention will be described.

Thus, the compound of the formula (I), preferably

mono-L-aspartylchlorin e6 or its salt, is administered at its appropriate dose to a patient whose blood vessel has received a therapeutic treatment by PTCA or PTA. Estimation is then made of a time point at which an effective amount of the administered compound has accumulated in the PTCA or PTA-treated site of the blood vessel. With choosing an optimal timing nearly before or after said time point which was estimated as above, the laser-irradiating device of Figure 1 is then introduced at the optimal timing into the interior of said blood vessel percutaneously and transluminally by the PTCA or PTA technique.

The positions of the balloon-forming part of the balloon catheter and the laser emitter of the optical fiber in the laser-irradiating device as introduced are then adjusted so that the balloon-forming part and the laser emitter are located in a position opposite to the angioplasty-treated site of the blood vessel which has been predetermined to be treated by the second aspect method of this invention. Said site is namely the blood vessel site having previously been treated by PTCA or PTA. Then, the body of the laser-irradiating device is held firmly within the blood vessel. Next, the inflating liquid (for example, sterile physiological saline or physiological saline containing an X-ray contrast medium) is delivered and introduced into the balloon-forming part of the balloon catheter through the

aforesaid inlet tube of the device under an appropriate liquid pressure. Thereby, the balloon-forming part of the balloon catheter is made to inflate and to produce the inflated balloon. The outer wall of the completely inflated balloon as filled with said liquid can thus be brought into a close contact with the inner wall of the blood vessel and has occupied the inner room of the vascular lumen of the blood vessel, to intercept the flowing of the bloodstream in the vascular lumen.

Then, the laser light is made to pass into the optical fiber of said device and is allowed to be transmitted therethrough and emitted from the emitter of the optical fiber and to pass across the inflating liquid medium present in the inflated balloon and also across the wall membrane of the inflated balloon, so that the inner wall of the blood vessel at the PTCA or PTA-treated site thereof can be irradiated with the irradiating laser light.

The administered chlorin e6 compound which has accumulated in the cells of the blood vessel inner wall at said PTCA or PTA-treated site can then be photo-activated by the irradiating laser light as emitted, to bring about an apoptosis of the vascular smooth muscle cells and to exert the suppressive effects against the intimal thickening which would be inducible in the PTCA or PTA-treated site of the blood vessel.

After making the irradiation of laser light for a

given period of time, the inflating liquid is discharged from the inflated balloon and from the device used. Subsequently, the whole of the laser-irradiating device is withdrawn out from the blood vessel. Then, the routine post-treatments are carried out to finish the therapeutic treatment as intended.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 of the appended drawings shows a diagrammatical view of the longitudinal cross-section of the laser- irradiating device which comprises a balloon catheter and can be used in the method of the second aspect of this invention.

Figure 2 shows a diagrammatical view of the longitudinal cross-section of the laser-irradiating device which comprises a balloon catheter having its balloon inflated after the insertion of the device of Figure 1 in the blood vessel.

Figure 3 shows diagrammatical view of the longitudinal cross-section of a balloon catheter which is insertable intravascularly and may be used to assemble and construct within the blood vessel such a laser-irradiating device that is available in the second aspect method of this invention.

Figure 4 shows a diagrammatical view of the traverse cross-section of the blood vessel at a site thereof having the intimal thickening as produced in the lower abdominal artery of rabbit which was tested in

Example 2 described hereinafter.

BEST MODE FOR CARRYING OUT THE INVENTION

The method of the second aspect of this invention will now be illustrated with reference to the following Examples, but this invention is not limited to these Examples.

Example 1

Mono-L-aspartylchlorin e6 tetrasodium salt (NPe6) was intravenously administered at a dose of 2.5 mg/kg to a rabbit weighing about 4 kg. A commercially available 2F balloon catheter was immediately then inserted through the femoral artery into the abdominal aorta of rabbit. Thereafter, there are repeated operations of drawing out from the blood vessel the balloon catheter with the inflated balloon, inserting the balloon catheter again into the blood vessel, and drawing out the balloon catheter with the inflated balloon, whereby a rabbit model with an arterial injury was produced. This method for producing the rabbit model having the arterial injury at the blood vessel inner wall was in accordance with the method of Hsiang et al. (see Ann. Vasc. Surg., Vol.9, p.80-86, 1995).

At the end of 3 hours after the administration of NPe6, an optical fiber for irradiation of laser (made of an acrylic polymer filament having an external diameter of 0.5 mm and provided with the emitter part of 15mm in length) was inserted into the hollow hole of the 2F

balloon catheter which had been inserted in and kept remained at the balloon-injured site of the abdominal aorta blood vessel. The balloon of the catheter was then inflated. Laser light of 664 nm wavelength was passed into and transmitted through the optical fiber to make the laser light to irradiate the abdominal artery at the balloon-injured site, and thereby to carry out the PDT treatment of said site at a laser fluence of 50 or 100 J/cm^2. The laser (of the wavelength of 664 nm) used was emitted from a laser-generating source of semi-conductor type known for PDT.

At the respective ends of four days, two weeks and four weeks after the above PDT treatment so made, the site having received the PDT treatment was pathologically studied. According to the pathological findings as obtained at the end of four days after the PDT treatment comprising the above-mentioned intravascular laser irradiation method, it was observed that the cells of the tunica media of the blood vessel at the PDT-treated site thereof were destroyed in a broad region of ranging from the inner wall side towards the outer wall side of the blood vessel. According to the pathological findings as obtained at the respective ends of 2 and 4 weeks after the PDT treatment, it was observed that the intimal thickening as produced by the vascular neo-intima formed at the PDT-treated site was inhibited, and that no injuries were developed in the

regions of the blood vessel which are participating in the entire construction of the blood vessel.

Example 2

Mono-L-aspartylchlorin e6 tetrasodium salt was intravenously administered at a dose of 2.5 mg/kg to three rabbits each weighing about 4 kg. Thereafter, there are repeated the operations of inserting the 2F balloon catheter through the femoral artery into the abdominal aorta vessel of rabbit, inflating the balloon of the inserted catheter, and drawing out the catheter from the abdominal aorta vessel with keeping the balloon inflated, whereby the rabbit model with the arterial injury was produced according to the aforesaid method of Hsiang et al.

Figure 4 of the appended drawings shows the diagrammatical view of the traverse cross-section of the blood vessel positioned at the site thereof having the intimal thickening which was produced as above in the lower abdominal artery of the rabbit and which was tested as the rabbit model of the arterial injury in this study. As shown in Figure 4, the blood vessel (5), which is seen at the position of the blood vessel site having the intimal thickening, has comprised the vascular adventitia (7), the tunica media (8) and the thickening intima, namely the neo-intima (9) as well as the vascular lumen (10). The neo-intima (9) had newly been produced from the inner side of the tunica media

(8) due to the injury as induced by the balloon-intervention.

At the end of three hours after the administration of mono-L-aspartylchlorin e6 tetrasodium salt, a device comprising an optical fiber for the irradiation of laser was inserted in the blood vessel of rabbit having the intimal thickening, to arrive at the balloon-injured site of the blood vessel. In order to estimate in comparison the achievable suppressive effects of the PDT treatments against the vascular restenosis, the above test procedures were conducted with employing two different types of the laser-irradiating devices comprising the optical fiber for the irradiation of laser, a first one type of which two different devices was such a laser-irradiating device that comprised an optical fiber as integrated with a balloon catheter and that is shown in Figure 1 of the appended drawing. The other type of the laser-irradiating device employed was comprising simply the conventional type of cylindrical optical fiber. In the tests, either one of these two different types of the laser-irradiating devices containing an optical fiber was inserted into the abdominal aorta under test. Under roentgenoscopy, an X-ray-shielding marker which had been provided in the laser-irradiating optical fiber so inserted was observed as a guide. This guide was used so that the position of the optical fiber device as inserted could be adjusted

so as to be located in a position optimal to make the laser to irradiate selectively just the balloon-injured site of the abdominal aorta under test. Then, the irradiation of the laser through said optical fiber was carried out at a laser fluence of 50 or 100 J/cm^2 by means of a semiconductor generator for generating the laser of a wavelength of 664 nm. However, when the first type of the laser-irradiating device comprising the optical fiber integrated with the balloon catheter shown in Figure 1 was employed for the intravascular irradiation of laser, there was interposed, prior to the laser-irradiation step, such additional steps that a sterile physiological saline was injected into the inlet tube of the inserted balloon catheter via a pressure pump and was delivered into the interior space of the balloon of the balloon catheter to make the balloon inflated. There was involved a completed inflation of the balloon of the balloon catheter comprised in said device as suitably located in the blood vessel. The completely inflated balloon then could produce such conditions that the flowing of the bloodstream was intercepted at said balloon-injured site of the blood vessel. When these conditions of the interception of the intravascular flowing of the bloodstream had been obtained by means of said completely inflated balloon, the irradiation of laser was then commenced to be effected. These procedures of carrying out the PDT

treatment with employment of the laser-irradiating device of Figure 1 are greatly different from the procedures as conducted in the case when the second type of the laser-irradiating device comprising simply the conventional type of cylindrical optical fiber was employed for the intravascular irradiation of laser. At the end of two weeks after the above operations of PDT, the PDT-treated site of the blood vessel was pathologically studied. From the photographies of showing the traverse cross-section of histopathologically stained test specimens as collected from the above PDT-treated site of the blood vessel, the area of the tunica media and the area of the neo-intima of the test specimens of the blood vessel under test were measured by an image analyzer. The ratio of the area of the tunica media to the area of the neo-intima of the blood vessel specimens was calculated. Using the so calculated ratio as an index, the inhibition rate (%) of the intimal thickening was estimated. In the control tests (untreated), the third rabbit under test has received neither administration of NPe6, nor irradiation of the laser.

The inhibition rate (%) above was calculated from the following equation:-

$$\text{Inhibition rate}\,(\%) = \frac{A - B}{A} \times 100$$

wherein A means the ratio of the area of neo-intima to

the area of tunica media in the control group (Untreated group) of rabbit under test; and B means the ratio of the area of neo-intima to the area of tunica media in the treated group of rabbits under test.

The test results so obtained are tabulated in Table 1 below.

Table 1

Suppressive effects of PDT (photodynamic therapy) treatment according to the method of this invention on the intimal thickening induced at the balloon-intervented and injured site of blood vessel

Features of Treatment Drug administered and Manner of irradiation of laser	Ratio of area of neointima to area of tunica media in blood vessel	Inhibition rate (%)
Untreated Group (with no administration of drug and with no PDT treatment)	1.22±0.32	—
Treated Group (comparative) with administration of 2.5 mg/kg of NPe6 and with laser-irradiation by the conventional type of cylindrical optical fiber device for irradiation of laser at influence of 100 J/cm^2	0.87±0.37	28.7
Treated Group (inventive) with administration of 2.5 mg/kg of NPe6 and with laser-irradiation by the optical fiber device integrated with the balloon catheter for irradiation of laser at influence of 50 J/cm^2	0.68±0.21	44.3

As clearly seen from the results of Table 1, it is confirmed that the PDT method, which was conducted with employing the laser-irradiating device comprising the optical fiber and the balloon catheter in an integral combination as shown in Figure 1, that is, the laser-irradiating device of Figure 1 comprising the optical fiber as integrated with the balloon catheter and capable of intercepting the intravascular flowing of the bloodstream, is able to achieve the suppressive effects on the vascular restenosis at the angioplasty-treated site of the blood vessel, to an enhanced extent than the PDT method which was conducted with employing a laser-irradiating device comprising simply the conventional type of cylindrical optical fiber.

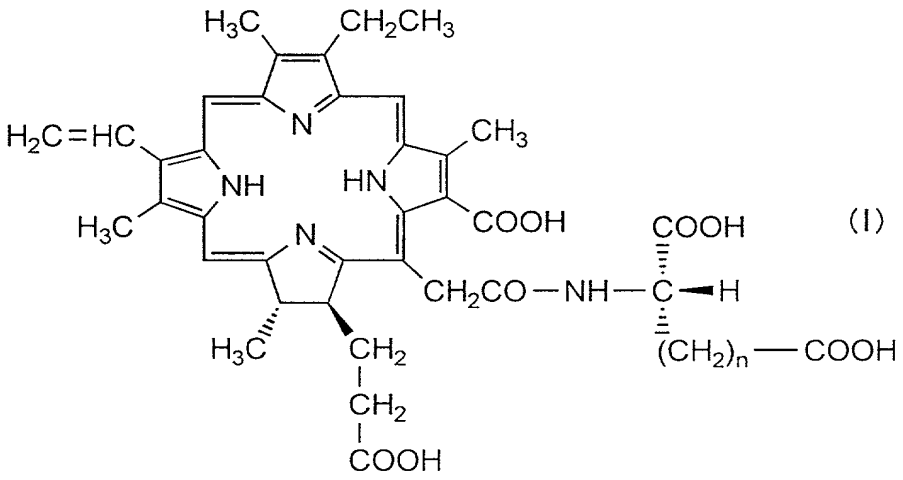
INDUSTRIAL APPLICABILITY

As described above, this invention provides a vascular restenosis-suppressing composition containing the compound of the general formula (I) or its salt as an active ingredient. This composition is useful for use in a photodynamic therapy to suppress the vascular restenosis inducible in the blood vessel at a site thereof having been treated by PTA or PTCA. In case a photodynamic therapy method is carried out with using the composition of this invention, the problem of the interference of bloodstream to inhibit the laser-irradiation and the problem of centering the laser-irradiating device within the blood vessel at the blood

vessel site to be treated by PDT can be resolved concurrently, if there is employed such a laser-irradiating device which comprises a balloon catheter and a laser-irradiating optical fiber as integrated with each other. In addition, as compared with the therapeutic effects obtainable by the conventional methods, more uniform and better therapeutic effects of PDT can be obtained according to the method of this invention.

CLAIMS

1. A vascular restenosis-suppressing composition, which is for use as a photosensitive agent in a method of suppressing the vascular restenosis inducible at an angioplasty-dilated site of a blood vessel having received a percutaneous transluminal coronary angioplasty or a percutaneous transluminal angioplasty, by means of a photodynamic therapy process comprising intravascular irradiation of laser, and which composition exhibits a suppressive effect on a thickening of the vascular intima in the interior of the blood vessel wall at the angioplasty-treated site of the blood vessel, characterized in that said composition comprises mono-L-aspartylchlorin e6 or mono-L-glutamylchlorin e6 having a general formula (I)



(I)

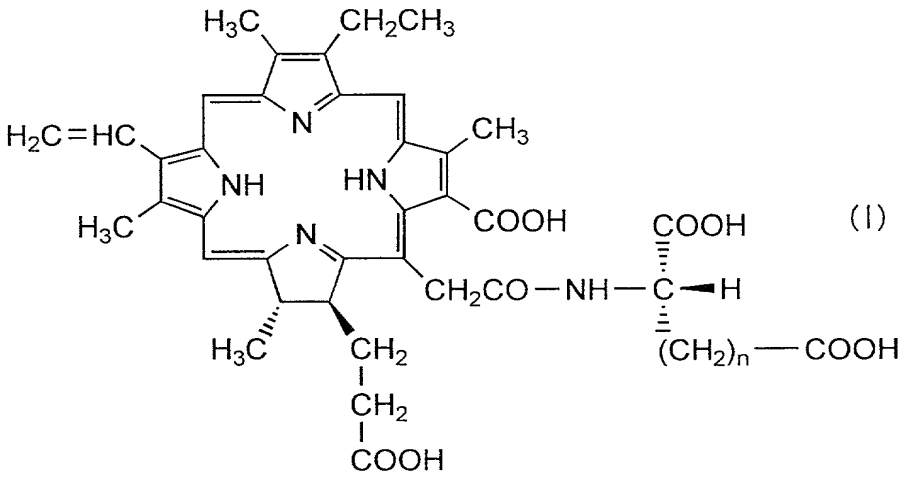
wherein n is an integer of 1 or 2, or a pharmacologically acceptable salt thereof, as an active

ingredient.

2. The vascular restenosis-suppressing composition according to Claim 1, characterized in that the compound having the general formula (I) or its salt is mono-L-aspartylchlorin e6 or its tetrasodium salt.

3. A photodynamic therapy method of suppressing such thickening of the vascular intima in the blood vessel wall and also such vascular restenosis of the blood vessel which are inducible after the angioplasty treatment of the blood vessel has been done, which method comprises:-

administering mono-L-aspartylchlorin e6 or mono-L-glutamylchlorin e6 of the general formula (I)



(I)

wherein n is 1 or 2, or a salt thereof, to a patient whose blood vessel has received the treatment by angioplasty;

making the administration of the compound of the formula (I) at a dosage so adjusted that a

therapeutically effective amount of the compound of formula (I) can accumulate in the cell layers of the blood vessel wall at the site of the blood vessel having received the treatment by angioplasty;

inserting percutaneously and transluminally into and locating in the interior of said blood vessel at the position of the site thereof having received the treatment by angioplasty, such a laser-irradiating device that comprises a balloon catheter having a central and longitudinal hole therein and having an inflatable balloon made of a laser-transmissive material at the front end of said catheter and that comprises a laser-irradiating optical fiber so arranged as to extend within and through said central and longitudinal hole in the balloon catheter and is equipped on the catheter with an inlet tube for introduction of an inflating liquid to be sent into the interior space of said inflatable balloon; and adjusting the position of the balloon catheter within the blood vessel so that said balloon of the balloon catheter is located oppositely to the angioplasty-treated site of the blood vessel;

making said balloon of the balloon catheter inflate by delivery of the inflating liquid in the interior space of the balloon of the catheter via said inlet tube for introduction of the inflating liquid into the balloon interior space of the catheter of said device, thereby to produce the inflated balloon in the balloon

catheter;

allowing the central axis of the laser-irradiating optical fiber present within the central and longitudinal hole of said balloon catheter to be held coincidently with and in the same position as the central axis of the vascular lumen of the blood vessel at the angioplasty-treated site of the blood vessel, with aid of such a supporting force which is generated by said inflated balloon to be exerted on the balloon catheter and on the inner wall of the blood vessel at said angioplasty-treated site;

and irradiating the compound of formula (I) having accumulated in the interior of the blood vessel wall positioned at the angioplasty-treated site of the blood vessel, with a laser light of an appropriate wavelength, by transmitting from a laser-generator the laser light via said optical fiber in the balloon catheter, in such a manner that the transmitted laser light is emitted outwardly from the laser-emitting part at the front end of said optical fiber and is made to pass through the liquid medium present in the inflated balloon and through the wall material of said inflated balloon of the balloon catheter, so that the emitted laser light irradiates the compound of formula (I) present in the blood vessel inner wall, whereby said compound so irradiated is photoactivated and allowed to generate and exert the suppressive effects thereof against the

thickening of the vascular intima in the angioplasty-treated site of the blood vessel.

4. The photodynamic therapy method according to Claim 3, wherein the angioplasty is a percutaneous transluminal coronary angioplasty or a percutaneous transluminal angioplasty.

ABSTRACT

A vascular restenosis-suppressing composition comprising mono-L-aspartylchlorin e6 or mono-L-glutamylchlorin e6 or a salt thereof as an active ingredient, is provided as such a novel pharmaceutical composition which is for use in a photochemotherapy, and which is capable of suppressing the vascular restenosis inducible in the blood vessel having received a treatment by a percutaneous transluminal coronary angioplasty or a percutaneous transluminal angioplasty. In addition, a photodynamic therapy method for suppressing the vascular restenosis inducible after the treatment by angioplasty is provided with using said pharmaceutical composition.

FIG. 1

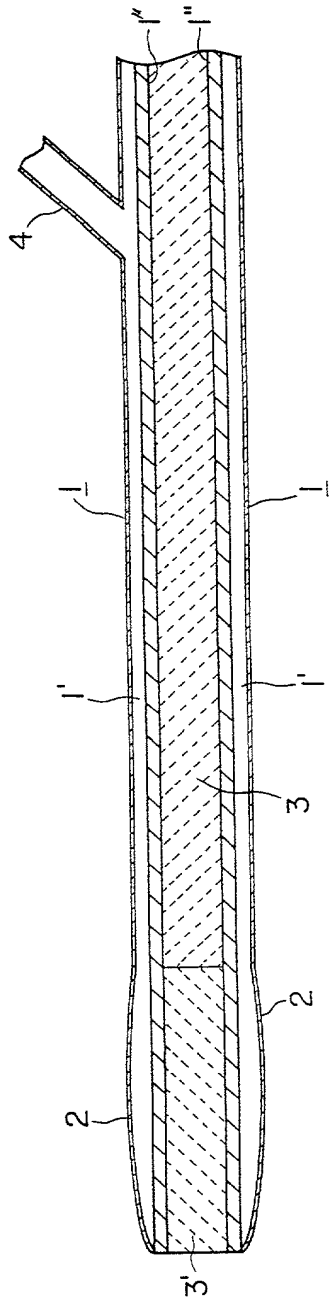


FIG. 2

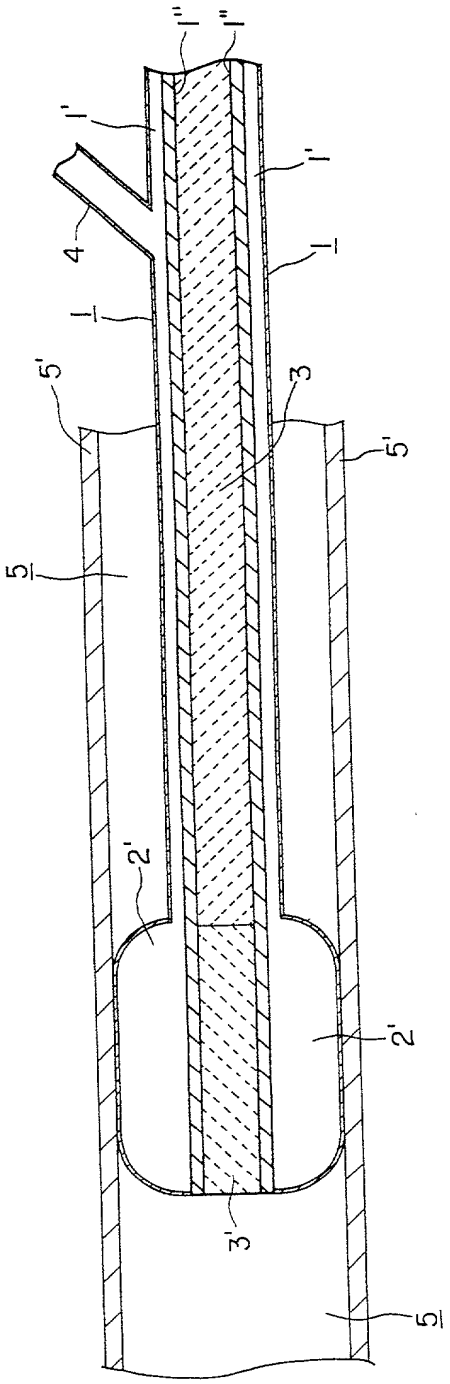


FIG. 3

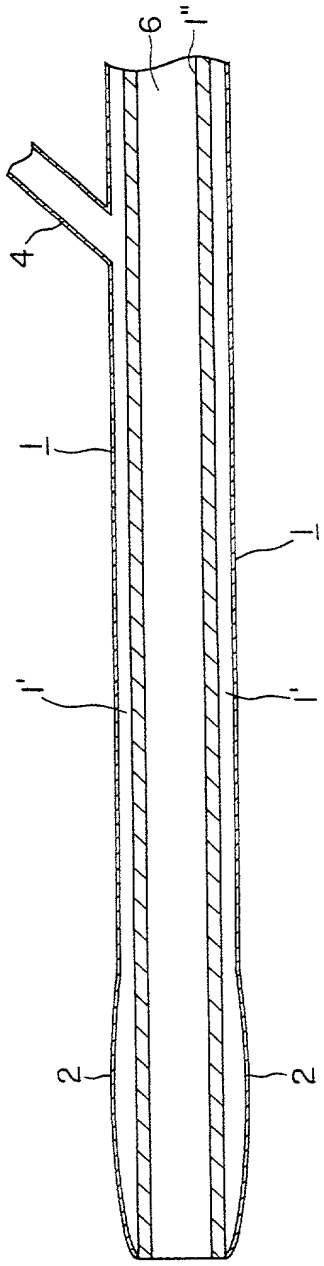
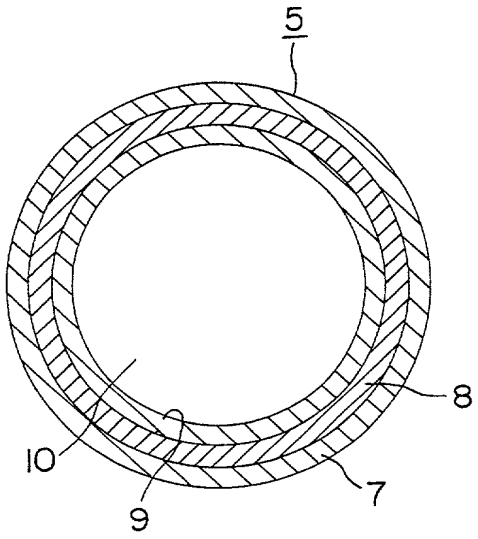


FIG. 4



DECLARATION FOR USA PATENT APPLICATION

(including Design and National Stage PCT) Attorney's Docket ID:

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: SUPPRESSANT AGAINST VASCULAR RESTENOSIS OF BLOOD VESSEL

the specification of which: INDUCIBLE AFTER ANGIOPLASTY

is attached hereto.

(or)

was filed on , was amended on (if applicable), and was filed as U.S. Application No. or PCT International Application No. . PCT/JP00/02156

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, where priority is not claimed, any foreign application for patent or inventor's certificate, or any PCT International application having a filing date before that of the application on which priority is claimed. (___ ADDITIONAL APPLICATIONS IDENTIFIED ON ATTACHED SHEET)

Prior Foreign Application No.	Country	Day/Month/Year Filed	Priority Not Claimed
11-95654	Japan	2 April 1999	

I hereby claim the benefit under 35 U.S.C. 120 of any U.S. application(s), or 365(c) of any PCT application designating the U.S., listed below; and insofar as the subject matter of each claims of this application is not disclosed in the prior U.S. or PCT application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT filing date of this application. (___ ADDITIONAL APPLICATIONS IDENTIFIED ON ATTACHED SHEET.)

U.S. or PCT Parent Application No.	Parent Filing Date (Day/Month/Year)	Parent Patent No. (if applicable)

As a named inventor, I hereby appoint the registered practitioners of LARSON & TAYLOR associated with **Customer Number 000881** to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith. Direct all correspondence to that Customer Number.

Direct all telephone calls to .

at TEL. (703) 739-4900 (Fax: 703-739-9577) e-mail:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1000 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SOLE OR FIRST INVENTOR	Citizenship: Japanese
Given Name (first and middle [if any]): Tsuneyuki	Family Name or Surname: NAGAE
Full Post Office Address: c/o Tokyo Medical College, 1-1 Shinjuku 6-chome, Shinjuku-ku, Tokyo 160-0022 Japan	
Residence - City, State/Country (if different from PO address): Same as above	
SIGN AND DATE HERE Inventor's Signature: Tsuneyuki Nagae	Date: 2nd July 2001

SECOND JOINT INVENTOR (if any)	Citizenship: Japanese
Given Name (first and middle [if any]): Katsuo	Family Name or Surname: AIZAWA
Full Post Office Address: c/o Tokyo Medical College, 1-1 Shinjuku 6-chome, Shinjuku-ku, Tokyo 160-0022 Japan	
Residence - City, State/Country (if different from PO address): Same as above	
SIGN AND DATE HERE Inventor's Signature: Katsuo Aizawa	Date: 2nd July 2001

THIRD JOINT INVENTOR (if any)	Citizenship
Given Name (first and middle [if any])	Family Name or Surname
Full Post Office Address	
Residence - City, State/Country (if different from PO address)	
SIGN AND DATE HERE Inventor's Signature	Date

FOURTH JOINT INVENTOR (if any)	Citizenship
Given Name (first and middle [if any])	Family Name or Surname
Full Post Office Address	
Residence - City, State/Country (if different from PO address)	
SIGN AND DATE HERE Inventor's Signature	Date